TechNotes
Getting the most up-to-date information on materials testing
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Issue 47

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Geomembranes – Protecting Our Water from Our Waste


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Product packaging, diapers, grass clippings, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. These products are added to our landfills every day and they decompose and mix with rainwater to form a chemical soup known as leacheate. Decomposition also produces gases such as methane and carbon dioxide. These byproducts of the landfill, if allowed to contaminate the groundwater, would quickly render it difficult, if not impossible, to treat our water and make fit for consumption. The methane, if allowed to build up, could form an explosion hazard. Clearly, the modern landfill is not just a hole in the ground.

The main item in the landfill that makes it possible to exist atop the water table is a thermoplastic liner called a geomembrane. The physical demands on the geomembrane are substantial and a wide range of tests are used to ensure it can do its job for many years.

The US Environmental Protection Agency has estimated that in 2009, Americans produced about 243 million tons of solid waste, or about 4.3 pounds of waste per person per day. Currently, in the United States, 33.8% of our waste is recovered and recycled or composted, 11.9% is burned at combustion facilities, and the remaining 54.3% is disposed of in landfills.

Landfill planning and construction is a major scientific and civil engineering project. Federal and state regulations strictly govern the location, design, operation, and closure of landfills to protect human health and the environment. The bottom liner system is carefully designed to retain the waste and the byproducts and keep it from polluting the environment, particularly the groundwater. Systems are incorporated into the structure to remove rainwater, leacheate, and gases.

Geomembranes

Geomembranes are relatively thin sheets of thermoplastic material, the most common being polyvinyl chloride (PVC) or high-density polyethylene (HDPE). These sheets are seamed together to form a contiguous covering for the base of the landfill site. When the landfill is full, it is closed and the site is capped with a further covering of geomembrane, fully enclosing the landfill contents.

Mechanical Properties

Landfill geomembranes are subject to substantial loads during installation and in service. If there are rocks, pieces of metal or glass on the ground when the geomembrane is laid down they make the geomembrane susceptible to puncture. The forces required to install the geomembrane exert loads on the material, in particular at the seams joining the individual sheets.

In service, the geomembrane is subjected to shear loads at the sloping sides of the landfill due to the weight of the landfill contents. Enormous spiked-wheel bulldozers level and compact the landfill materials, and the forces necessary can be transferred to the geomembrane.

The important mechanical properties of the geomembrane include the performance under tensile loads; tear, impact, and puncture resistance; interface shear strength between the membrane and other materials; and shear and peel mode seam failures.

Environmental, Chemical and Biological Resistance

Environmental, chemical, and biological properties determine how the geomembrane liner withstands degradation over time.

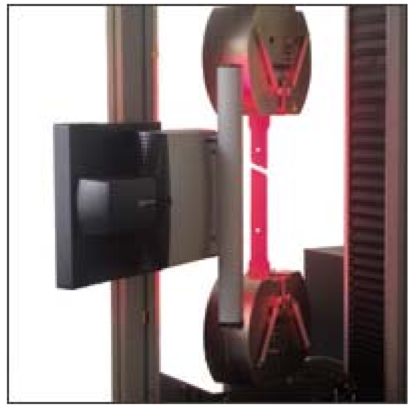
Aging and degradation in the geomembrane changes the semi-crystalline polymers, increasing the risk of stress cracking.

The liner must withstand the chemicals that are part of the leachate. If the geomembrane breaks down under chemical attack, the mechanical and physical properties weaken, making the geomembrane more susceptible to cracking and tearing.

During the life of the landfill, much of the geomembrane liner is exposed to the sun. Ultraviolet rays from the sun break down the polymer structure in the geomembranes.

Testing

Tensile Strength



The classic uniaxial tensile test assesses the mechanical values of the geomembranes, that is, tensile strength and strain at break and yield points, and secant tensile modulus at 10% strain. These tests are very common and easy to use, particularly with non-contacting extensometers, and they set the basic properties of the products.

The biaxial bursting test involves pressurizing a sample of geomembrane with air while it is clamped in a circular opening. The geomembrane forms a dome that grows under pressure to the point of burst failure. The test establishes a relationship between air pressure and increase of the dome dimensions.

Shear Testing

Shear strength between a geomembrane and a soil is responsible for keeping the slopes of the landfill from collapsing. One of the easiest methods of improving the shear strength at the geomembrane-soil interface is to use a textured geomembrane to increase the friction between the membrane and the soil. However, this tends to turn the membrane into a load-bearing member of the system. Placing the soil and the geomembrane next to each other and putting normal forces on both tests the strength of this interface.

Puncture Resistance

Thick geomembranes increase puncture resistance but increase material costs and installation costs. So testing puncture resistance is vital when trying to balance cost-effectiveness with long life. Several puncture resistance tests are used.

A common test involves a membrane sample clamped in a ring. A 50 mm diameter plunger is pushed against the center of the sample, extending it until failure. The maximum load and plunger displacement at puncture are recorded.

In the truncated cone test, a geomembrane specimen is placed in a chamber, held in place by sixteen clamps, and placed in contact with three truncated cones. The chamber is then filled with water. Air pressure or water pressure is used to press the cones through the geomembrane to the point of puncture. A pressure valve measures the pressure difference between the point right before and right after the puncture, establishing a value for its puncture resistance.

Seam Testing

Geomembrane seam strength and security is as important, if not more important, as the properties of the geomembrane itself. The properties of the seams are vital in determining the total strength of the liner. Seam strength is tested destructively while seam security is tested non-destructively.

There are three main ways to test seam strength: shear, T-peel, and 180° peel. The T-peel is sometimes referred to as the 90° peel. Placing one side of the seam in one set of clamps and the other in another set, the seam is effectively ripped apart and the amount of force the sample is put under is quantified. From this number the experimenter can find both the maximum and residual stress for the seam.

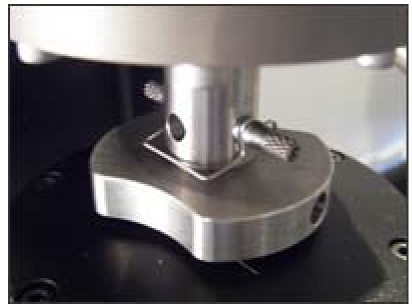
Non-destructive testing examines seam continuity and locates holes in the seam. However, it doesn’t test for seam strength.

Environmental, Chemical and Biological Resistance Testing

While it is possible to develop accelerated aging and resistance tests in the laboratory, these still require some years of testing to fully evaluate the responses and results. Empirical tests from real systems are by far the best indicators of changes in the geomembrane over time. It is typical to remove a piece of geomembrane from a liner that has been withstanding normal conditions for a number of years and run normal physical and material properties testing on it. Many times to test durability, tests are run on geomembranes that were previously part of a landfill liner.

For new landfill applications, the chemical resistance of the proposed geomembrane to the leachate is assessed by EPA Method 9090 Compatibility Test for Waste and Membrane Liners. In this test, the geomembrane is exposed to leachate at 23 and 50° C for 120 days. Changes in properties are measured every 30 days. If there is no continuing degradation trend, or if changes reach an equilibrium condition within certain limits, the geomembrane is considered to be compatible with the leachate.

Accurate Testing Starts with the Preload



Often when visiting customer sites, our service engineers find machines that have basic setup problems that can have a large effect on the accuracy of test results. A very common problem is testing with poorly preloaded grip locknuts. Placing a specimen under tension also places all items in the load string – grips, grip adapters, load cell, and so on – under tension as well.

Grips Supplied with Locknuts

If the locknut is insufficiently tight, the forces experienced during a test, particularly a cyclic test, can cause backlash in the load string leading to errors in the test data. Before testing, make sure that you preload the load string, using a load greater than the expected maximum load, and tighten the grip locknuts while the load is applied.

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A. We test the calculations in every update or new release of Bluehill® software using the following methodology:

We import a standard set of data into Bluehill 3 and perform a full set of calculations, comparing the result of each calculation against a result previously verified as accurate. We repeat this process using several different data sets for each calculation.

Our software has thousands of users worldwide, incorporating applications from all areas including biomedical, food, aerospace, electronics, textiles, plastics, metals, and composites. Many users have independently verified the accuracy of Instron® test calculations through comparisons with manual calculations and measurements, and correlation with past test results.

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